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THE SCIENTIFIC APPROACH TO COLONIAL DEVELOPMENT

LORD HAILEY, in an article under this title which recently appeared in *Nature** reviews prevailing conditions in the British Colonial Empire and stresses, in particular, the importance of careful planning for the improvement of the standards of life of its peoples. The social services needed to improve these standards must, if they do not already exist, be created and financed. "We must", he says, "see that the colonial peoples have that type of nutrition which will establish the necessary measure of resistance to disease. We must secure for them a subsistence adequate to provide the strength necessary for sustained effort in cultivation or industry. They must have access to medical facilities for dealing with physical disorders, epidemic or otherwise; and access to such measure of popular instruction as will enable the mass of people to adjust themselves to the needs of new economic and cultural conditions. These are fundamentals, and precondition all further social progress".

"But planning, even at this early stage, cannot halt there. We interpret economics to-day in terms of welfare not of wealth; but it is a condition of welfare that the Government should itself have the means of raising finance for capital works or for the provision of social services, and that the population should be furnished with the means of acquiring articles which a non-industrialized country must necessarily import. All the exportable assets of the territory, whether in the form of metals or of exportable crops, must therefore be turned to the best account. But this must at the same time be effected on terms which will avoid prejudice to the primary claims of subsistence production or undue disturbance to a social economy not yet adjusted to the needs of industrial life."

How far have we planned scientifically for development on these lines? For, surely, "the use of science in colonial development means just this, that we start by surveying the whole field in order to get the problems which it presents into proper alignment, and afterwards proceed systematically to their solution, using the most

* Vol. 148, No. 3759. 1941. Substance of a paper read at the Conference on Science and World Order. September, 1941.

expert agencies available for advice as to the methods to be employed, and expending the resources at our command in the order which the relative importance of our problems indicates."

"It is doubtless unduly idealistic to suggest that we could ever have proceeded on lines involving so much prevision and systematic procedure as this involves. It is at all events clear that we did not do so. We have, for example, in many instances allowed concentration on the cultivation of export crops to outweigh the needs of subsistence production, with results no doubt less disastrous than those which at one time attended the use of the culture system in the Netherlands East Indies, but sufficiently grave to require legislation compelling a minimum subsistence cultivation, in order to prevent famine. It is only in the last few years that we have inaugurated a general survey of nutritional conditions in the Colonies. . . It is only of very recent years that we have realized the widespread menace of soil erosion and the need for special measures for conserving soil fertility. . . Or take yet another field. Native land tenure systems have in Africa still to come under comprehensive survey, though agricultural progress must largely depend on the evolution of a definite and easily recognizable system of land rights. Recruitment of labour for industrial enterprises has not until lately been regulated by any programme based on the capacity of different areas to provide man-power without undue social disturbance or interference with subsistence cultivation. It has been left to the management of these enterprises to investigate the most suitable dietary for labour and to apply it at their own discretion."

". . . Our colonial policy has in the past been dominated by certain traditions derived from our own political instincts, and by the conditions in which we originally acquired jurisdiction over our dependent peoples. We saw our first duty in protecting them from exploitation and misrule and in fitting them to maintain, in a political sense, their own position in the world. That tradition was far from unworthy, but it may be that it unduly diverted our attention from the need of pursuing a constructive policy of improvement in the physical conditions and the standards of life of these people. In the second place, we have in the past tended in our own domestic life to look on the State chiefly as a political organization, and not as one of which the primary function is the promotion of the social welfare, the health and the standards of life of its citizens. This generation has seen a radical change in our conception of the functions of the State, and with it has come a new and more constructive outlook on the activities which should engage the attention of a colonial administration."

"This changed conception of the functions of the State has had a marked influence on the attitude of the British public itself towards its colonial obligations. . . It is the general acceptance of this new conception of the State in relation to the provision of social services which rendered it relatively easy to secure the liberal provision of funds guaranteed by the Colonial Welfare Act passed in 1940. . . ."

"It is now the task of the administrator to make a full use, and at the same time a more scientific use, of this position." Here, Lord Hailey indicates some of our more fundamental needs in which he includes, among others, the placing on a more satisfactory basis of our demographic information, the extension of land surveys, the expansion of our geological survey services, and the continuation of nutrition surveys, a movement largely stimulated by the work of Sir John Orr and his colleagues in Kenya. The absence in many territories of a complete survey of health conditions is pointed out. Lord Hailey suggests that studies on the social side should also be undertaken such as that into land tenures, and on the procedure of native marketing. Much of this work, it is hoped, will become practicable when the special fund for research by the Act of 1940 becomes available after the war. "But survey, though essential to systematic planning, is only part of a scientific approach to colonial development. There still remains the need for research into the wide range of specific problems arising in the field both of the applied and social sciences, which require local investigation either because they are peculiar to colonial conditions or because, though more general in character, they present features which can only be studied within the Colonies themselves".

There are here certain guiding considerations. "It is advisable that the facilities afforded by our great imperial institutions of research should be utilized to the fullest extent and that the energies of colonial research workers should be strictly limited to problems requiring local inquiry. One is struck by the limitations imposed on the research worker by isolation alike from the assistance and the criticism of professional colleagues. . . Secondly, we should seek to group colonial research workers into suitable centres and to bring their work under some form of professional direction. At present the staff engaged in research is liable to have its energies diverted to routine work, and when it undertakes longer range inquiries, the subject is often dictated by its own choice or pressed on it by the local interests which are in a position to influence its services".

"There arises a further problem. . . It is possible to envisage group centres for agricultural, medical or similar research each under its own professional direction. But how are the efforts of these different departments of inquiry to be coordinated ? Few of the major problems of the Colonies can be solved by specialists in one branch of inquiry alone. What agency is there which can exercise joint direction over these different interests in research, or at all events decide the relative importance of their application in practice ? That is a question to which the lay administrator would certainly welcome an answer."

SWOLLEN SHOOT AND DIE-BACK OF CACAO

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In a previous paper (1) we described the causes and the symptoms of the various types of cacao die-back in the Gold Coast and Nigeria.

Regarding the newly discovered Swollen Shoot disease we wrote (*loc. cit.* page 27) : . . . "Our observations led us to agree with Dade (2) that Swollen Shoot, while it presents a novel problem whose early solution is highly desirable, is only an incident in the general problem of cacao die-back." In this opinion we were mistaken. The nature and the symptoms of Swollen Shoot have been investigated by Posnette (3, 4), and the results of his work make it clear that, quite apart from the annual die-back caused by Capsid bugs, drought or unsuitable soil, an entirely new and most destructive disease of cacao has become established in the Gold Coast.

We have fortunately been able to revisit the Gold Coast, this time in the middle of the 1941 rainy season, when the symptoms of Swollen Shoot were neither masked by the effects of Capsid attack nor attributable to any effect of drought.

Posnette (4) has already described in detail the symptoms of Swollen Shoot. We wish to emphasize the chief characteristics of the disease which distinguish it from the ordinary forms of die-back.

The first indication of infection in a cacao tree is the appearance of a distinctive yellowish or whitish chlorosis in the leaves, the veins remaining outlined in normal green colour but seeming to be thickened underneath. Completely healthy looking leaves are never afterwards produced, though the degree of chlorosis varies considerably in later flushes. A steady defoliation follows and as the rate of leaf production is reduced, there is a tendency for the foliage to appear as small tufts at the ends of bare whippy branches. At this stage the whole appearance of the tree is yellowish. The Swollen Shoots, which give the disease its name, are later symptoms. They result from an increase in the width of the woody tissues and they are larger in chupons than in branches. Infected trees also produce characteristic small round pods. Die-back follows the defoliation, and though chupons may be produced from the trunk, the tree is nearly always dead within twelve months.

In any one farm Swollen Shoot first appears in individual trees. From these it spreads in circles which expand steadily until the whole area has been destroyed. The spread of the disease seems to be quite independent of the age or the condition of the trees, the presence of overhead shade or the type of soil.

As shown by Posnette, Swollen Shoot probably originated in the Nankase-Akodum district at least as early as 1930. Already the main area of infection approaches 250 square miles, and the continuous nature of the cacao belt provides ideal conditions for the spread which is now taking place. In the heart of this district probably two-thirds of the cacao has been destroyed, and in villages like Akodum stacks of cacao trunks are now to be seen for sale as firewood. This is where we originally thought the cacao had died as the result of repeated attacks by Capsid bugs (1, page 30).

A disturbing feature of the spread of the disease is the large number of isolated outbreaks appearing in healthy cacao bordering on the main area of infection. Thus at Tafo nearly seventy individual outbreaks have been discovered during the past two years. On the other hand, the rate of spread in any one individual outbreak is steady but not rapid ; probably a depth of three to four trees all round is the maximum in a year.

The Agricultural Department is carrying out a survey of the cacao producing areas, and so far thirteen isolated outbreaks of Swollen Shoot have been discovered in other parts of the Colony. The most distant of these are at Wiawso in the Western Province and at Peki in the Eastern Province, across the Volta River. There are also unconfirmed reports from Africans that the disease has appeared in French Togoland.

As regards control measures the primary object of the Department of Agriculture is to confine the disease within the existing limits of the main area of infection and to eradicate the isolated outbreaks as they are discovered. Such measures are at present severely handicapped by incomplete information about the distribution of the disease, the alternate host plants of the virus and the insect vectors.

We take this opportunity to stress the importance of Posnette's work and the potential threat of Swollen Shoot to the West African cacao industry. At the same time we consider that the older problem of die-back due to Capsid bugs, which is common to both the Gold Coast and Nigeria, equally requires immediate and intensive investigation.

Acknowledgment

We wish to record our deep appreciation of the facilities given us by the Gold Coast Agricultural Department during our latest visit.

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THE CULTIVATION OF SWAMP RICE IN SIERRA LEONE

BY

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A STUDY of literature describing the cultivation of this very important crop in the many countries where it is grown, discloses wide variations in treatment, great diversity of conditions under which it is grown and great differences in the cost of production. Sierra Leone is undoubtedly a "Land of Canaan" compared with most other countries and a brief description of swamp rice cultivation in this country may be of interest. The staple food of the country is rice and, although dryland rice farming on the shifting cultivation principle, is responsible for a very large proportion of the country's food supply, it is clear that the interests of the country will be best served by the fuller use of the abundant swamp lands for the cultivation of rice. In this article I will confine my remarks to tidal swamp lands. The use of inland swamps for rice cultivation has been advocated for many years and has now become an important feature in the agricultural aspect but methods are, in general, similar to those employed on tidal swamp lands.

HISTORY

Rice is believed to have been first cultivated in the tidal areas about 1880 when it was introduced on the Scarcies rivers, which enter the sea north of Freetown. Information available is not very reliable but it is believed that at first, germinated seed was sown on the mud of the flats bordering the rivers. This gave a very uneven stand and it was found that rice could be transplanted from the thick areas to the blank patches. This was done by hand at first but later someone, wiser than his fellows, invented the planting tool which is now almost universally used. Cultivation was probably first practised in patches of sedge or raphia land but it was soon discovered that the extensive mangrove belts along the rivers were highly suitable and within a few years large areas of forest had been felled, cleared and brought into cultivation. As a result of a survey in 1930 it was estimated that over 40,000 acres of mangrove swamp had been cleared along these rivers and were producing rice. This method of farming ultimately spread to rivers in the south-west, but it is only after Government actively fostered this industry, that development proceeded rapidly in other parts of the Colony.

CLIMATE AND SOIL

In the tidal areas the annual rainfall is about 125 inches. July, August and September are months of heaviest rainfall when the monthly precipitation is about 25 to 30 inches. There is a very pronounced dry season from mid-November until early May. The rivers start to flood about the beginning of June and do not return to their dry season level until the end of December.

A typical swamp soil is a dark grey, heavy, alluvial mud with a fairly high percentage of clay and, depending on how long it has been under cultivation, a varying amount of organic matter, mainly partly-decomposed mangrove roots. Sandy soils are as a rule unsuitable but, in areas where the rivers carry abundant silt, successful rice crops are grown in almost pure sand, the sand serving merely to support the plants. For detailed information on the nature of these swamp soils readers are referred to an article by Doyne and Glanville published in this Journal.*

PRODUCTION

No accurate statistics are available. In 1927 a Commission of Inquiry estimated the total production as 164,500 tons of clean rice. The 1940–41 crop has been estimated as at least 180,000 tons. Of this total production probably only between 20,000 and 30,000 tons of clean rice are produced from tidal swamp areas. Before the war only about 10,000 tons of the total crop came on the market. Until a few years ago a "hungry season" was generally experienced but now, given normal conditions again, an ever growing surplus exists for export.

SIZE OF HOLDING

Again no reliable statistics are available. Glanville estimates the average holding on the Scarcies at three acres but the land tenure question is very complicated as the family farm is commonly divided into small farms for the important members of the family. It is thought that an economic farm for a man and his family, who would be primarily a swamp rice farmer, would be about 5 acres.

VEGETATION

A typical swamp rice river, before cultivation begins, shows belts of mangrove, of varying width, from the sea almost to the limits of tidal effect. The mangrove is generally pure stands of *Rhizophora racemosa* but, particularly near the sea and in the upper mangrove reaches, isolated trees or small patches of *Avicennia nitida* are seen. Towards the inland tidal extremity, mangrove gradually merges into *Drepanocarpus lunatus*, *Raphia gracilis*, occasionally *Pandanus* sp. and often pure stands of *Raphia gracilis* along

* *Tropical Agriculture*, X, pp. 132-138, 1933.

the small tributaries beyond the tidal effect. On some rivers there are very extensive grass and sedge lands where rice is successfully grown. Such lands are usually dependent on flood rain water for irrigation instead of tidal irrigation. "Irrigation" is used in a very loose sense.

Mangrove Lands

Such lands are the most intensively cultivated and represent probably some 80 or 90 per cent. of the tidal lands at present under cultivation. Felling of the forest is an expert's job and skilful use is made of prevailing winds so that in properly felled forest all trees fall in the same direction. Felling is usually done in the dry season but this is only because weather conditions are less unpleasant then. The felled area is seldom touched for two years after felling. At the end of that time the trees are fairly well rotted and all except heavy trunks are piled in heaps on the farm and burned. Planting then begins, but it is believed to take eight or ten years before the heavy logs have disappeared. A Teredo, which burrows in the trunks, greatly assists disintegration. The timber has a limited local demand for building and as firewood for domestic purposes, bakeries and the smoke-curing of fish. The bark is used for tanning and the staining of woodwork. Attempts to establish an export trade in mangrove bark or timber have so far been unsuccessful.

Cultivation Methods

Nurseries are nearly always made on the uplands. A light, friable soil is favoured and bush is brushed and burned as for upland farming. Vacant areas in villages are commonly manured with house refuse and used as nurseries. In some areas seed is sown in the drier parts of swamps but wet nurseries, in the accepted sense, are unknown. The sowing rate varies from about 300 to 500 pounds per acre. A bushel of seed (62 lb.) gives seedlings for one acre of swamp. Seedlings grow in the nursery for 6 to 8 weeks. When pulled, they are tied in small bundles that can be conveniently held in one hand. These small bundles are made into compact headloads for transport. The plants are pruned to about 10 inches and, if necessary to facilitate separation, the roots are washed free of soil. June is the main sowing month.

On typical mangrove farms no cultivation is given. If necessary the farm is weeded before planting but the growing crop is not weeded.

In transplanting, an implement made of wood or iron is commonly used. It may be likened to a screw-driver with the flanged point exaggerated and a V cut in it. The gap between the points of the V is about one inch. Spacing is variable but about 9 to 12 inches between stands is common. The number of plants per stand is very variable and varies with the strength of the seedlings. 3 to 5 plants per stand is usual for good seedlings but 10 and over are often seen when the seedlings are weak. July to mid-September is the main planting season, the date of the operation frequently depending on the removal of salt from the soil and tide water by rain and fresh flood water.

Harvesting is all done by hand. A small knife is used, the reaper gathering about fifteen straws in his hand and cutting them with one stroke. Women and children cut one straw at a time. The heads, with about a foot of straw attached are tied in small sheaves and left lying on sticks or platforms or high ground to dry. Two or three days later the sheaves are gathered and stacked in small round ricks of roughly orthodox shape. December and January are the main harvesting months.

Thrashing is done by treading with the foot or beating with sticks. Winnowing is done with tray-like fanners which are very effective in skilful hands, provided a good breeze is blowing.

Most of the rice consumed is parboiled. It is de-husked by beating in a wooden mortar using a long wooden pestle.

Under native farming conditions the yield from swamp farms is about 1,200 pounds of padi per acre but land is not very efficiently used and yields of 2,000 pounds can easily be obtained. Yields have risen considerably since the Agricultural Department introduced improved varieties.

It is not possible to give the cost of production as labour is seldom hired, and when it is, remuneration is often in kind. Since there are no cultivation and manuring expenses the cost of production, relative to other countries, must be very low.

Varieties

Before introductions were made by the Department, about twenty native varieties of swamp rice were grown. These are being very rapidly replaced by improved varieties. Within the last eight years some fifty varieties have been introduced from various parts of the world and undergone trial on experimental stations. Pure line selection has been carried out with the best of the native varieties and careful comparative yield trials are always carried out before new introductions are put into circulation. At present the most popular varieties are Kavunginpoothala, G.E.B. 24, Sughandi, No. 79 and Ro. 1 (a pure-line selection from a native variety). Where conditions permit, long duration varieties are desired but short duration rices like No. 79 and Demerara Creole are also popular as they catch the early market, provide food while the main harvest is being reaped, and, where salt limits the growing period, a quick variety can often be grown. Salt resistant varieties, Bali and Mo-kuk, have been introduced but the superiority of their resistance is not very marked.

Diseases and Pests

Piricularia oryzae sometimes causes serious damage in the nurseries but seldom affects the plant after transplanting. An uncontrollable factor, weather conditions, appears to be an important factor governing the incidence of the disease and the breeding and introduction of resistant strains or varieties is not being overlooked.

Insects are not troublesome except in the stored grain where a weevil (*Calandra oryzae*) and a moth *Sitotroga cerealetta* do considerable damage.

Particularly in the upper river reaches, fish often do damage by eating the newly transplanted seedlings. Mangrove perch and mullet are the worst offenders and protective fences are made along the river banks. Hippopotami and a species of Manati cause localised trouble. Monkeys, crabs and birds are important pests.

How Development is being Fostered

In this country of high rainfall, where shifting cultivation is the normal farming practice, erosion is a very serious problem. The uplands are quickly being depleted of their protective covering of forest and the more extensive and intensive cultivation of the abundant swamp lands is accepted, at present, as the only practical solution of the difficulty. Inland swamp cultivation is being fostered but it is generally accepted that some movement of population from the uplands to the tidal swamp areas is necessary before any appreciable forest regeneration will take place.

Agricultural surveys of the tidal swamp lands have been carried out and reveal that only about 65,000 acres out of some 530,000 acres of potential rice lands are utilised. Of this 530,000 acres it is estimated that some 200,000 acres can be brought into production with little more expense than the felling of the mangrove. An experienced Irrigation and Drainage Engineer has recently been attached to the Department and schemes are already on foot to reclaim considerable stretches of land where population is immediately available.

Chiefs and selected farmers from non-producing, but potential swamp rice areas, are taken to areas of intensive cultivation and the whole procedure of development explained to them. Propaganda is also carried out in schools. A Government rice mill has been working very successfully for several years. Cooperative marketing societies have been started and, of course, agricultural stations have been opened in the swamp areas. A fund has been created from which intending farmers in new areas of development can borrow money to assist them in hiring expert labour to fell mangrove. This loan is repaid by instalments on the third, fourth and fifth year after receipt of the loan. For the last three years the amount of the fund was £500 per annum and as a result some 2,000 acres have been felled of which a considerable area is already producing. This fund has now been increased to £2,000 a year. A revolving seed scheme operates widely. Good seed is given out on loan and after harvest the farmer returns at the rate of 1¼ bushels for each bushel borrowed. Pure seed and demonstration farms financed by native administration, are also being started. Proposals have also been made for a land settlement scheme whereby grants will be made to families from the impoverished uplands to enable them to move and settle near the tidal swamp lands. In these, and many other ways Government is implementing the policy of swamp development. When the immense area is taken into consideration, and the cheap production costs, not only will the people's food supply be assured but the prospects of a very lucrative export trade are undoubtedly good. It will be obvious, too, that a very considerable increase in supervisory staff will be needed to guide this development along the right lines.

Acknowledgment

I am grateful to my Director, Dr. F. J. Martin, for his helpful criticism and for his permission to submit this article.

COFFEE MANURIAL TRIALS IN JAVA

Manurial trials with coffee carried out by the Mid and East Java Research Station at Malang are discussed in *Bergcultures*, XV, 1000–10. The trials have been in progress for 9 or 10 years. Many results are tabulated and discussed and the following generalizations based on them are made. Intensive manuring of old coffee is almost certainly uneconomic. Intensive manuring of young coffee leads to rapid growth and early first cropping, but if manuring ceases the succeeding crops show decline, while if manuring is continued the probability is that it will be uneconomic. A light manuring with N on young plantations on poor soil might prove profitable, but if P is added the result will be uneconomic. (Soils deficient in these nutrients are not here considered. Obviously they must be supplied if only as a matter of insurance.) Each young coffee plantation should have its own manurial trials properly laid out and the results of these should be applied to the whole. The organic refuse from a plantation should always be returned to the soil, whatever the results of any organic manurial trials may be, and without any attempt to assess the value economically. Leguminous cover crops, particularly in the form of *Leucaena* shade trees, of which the leaves and branches form a good mulch, are very valuable but whether these cover crops should themselves be manured needs further research. Research on methods of manuring coffee should only be conducted when it is possible to combine field work with physiological investigations.—(*Horticultural Abstracts*, XI, No. 4.)

FUMIGATION OF INSECT PESTS IN STORED PRODUCE

BY

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Introduction

THE storage of grain and other produce for short periods is usually possible without serious injury, but, especially under tropical conditions, severe infestation by insect pests may occur with long periods of storage, resulting in heavy losses. The adequate protection of stored produce from such infestation necessitates the use of specialized methods of pest control, such as cold storage and fumigation. Where cold-storage facilities are available, grain and other stored produce can be effectively protected from insect injury by holding them at temperatures below about 45° to 50°F. It is, however, often impossible or impractical to use cold storage, and it is therefore necessary to resort to fumigation.

Fumigation methods in general use for stored produce may be broadly divided into three categories: (1) The large-scale fumigation of ships and barges, flour mills, warehouses and other buildings, (2) the fumigation of small store-rooms, specially constructed chambers and storage bins, and (3) vacuum fumigation. Fumigation may be carried out either at atmospheric pressure or under partial vacuum.

Atmospheric Fumigation

The simplest type of fumigation chamber is the atmospheric fumigation chamber, consisting essentially of a specially constructed gas-tight room with a refrigerator-type gas-tight door, and equipped with an exhaust blower to dispel the gas after fumigation. Fumigation is carried out under ordinary atmospheric pressure. This type of fumigation chamber is satisfactory for the fumigation of grain and other stored produce, if sufficient time is allowed for the gas to penetrate by diffusion through the material fumigated.

Vacuum Fumigation

The vacuum fumigation chamber consists of a gas-tight steel chamber, usually cylindrical in shape, fitted with a door, the gasket of which provides a gas-tight seal. The chamber is equipped with a vacuum pump capable of drawing a vacuum of 28 inches of mercury. The material to be fumigated is placed in the vacuum chamber, the door closed, and the vacuum drawn. The fumigant is then admitted as a gas, and the remaining vacuum held for the duration of fumigation. In this way the air removed in drawing the vacuum is replaced by gas toxic to insects, there being an immediate penetration by the gas of the material fumigated, resulting in a more rapid and effective kill than that obtained by any other means.

At the end of the fumigation the gas is pumped out of the chamber and the vacuum broken with air. The air, which is allowed to rush in, causes the material fumigated to be "air-washed". This process of "air-washing" may be repeated, several times if necessary, by alternately drawing and breaking a vacuum with air.

Factors Affecting Fumigation

The initial infestation of grain and other stored produce by many insect pests occurs in the field. Early fumigation soon after harvesting, when relatively few insects are present, is more effective and profitable than later fumigation, when pests are noticeably abundant and have already effected considerable damage.

Fumigation should be carried out for preference in a vacuum fumigation chamber, but, if this is not available, in a gas-tight atmospheric fumigation chamber or in a store-room or storage bin made as gas-tight as possible. A fairly high temperature is essential for successful fumigation. This is not only because the insects are thereby rendered more susceptible to the fumigant, due to increased metabolic activity, but because the absorption of the fumigant by the material fumigated is then reduced to a minimum.

Different materials differ in their absorption of fumigants. In general, products rich in fats, such as nuts and cacao beans, absorb a great deal of gas, while products rich in carbohydrates, such as grain, take up only a small amount. Grain and other stored produce of negligible fat-content, when thoroughly dried, absorb relatively very little of most gases used in fumigation. The gas absorbed by the material is wasted as far as fumigation is concerned, as the absorbed gas does not affect the infesting insects.

Heavier-than-air fumigants diffuse downwards into the produce in a storage bin and, by displacing the lighter air, form a toxic concentration through the material. On account of absorption of the gas by the top layers of the substance fumigated, the concentration of the fumigant will vary inversely with the depth of the material. It is essential, therefore, to use a dosage of fumigant sufficient to allow for the absorption of the gas and yet to provide a toxic concentration of the fumigant at the bottom of the storage bin. The toxic effect of a fumigant depends on its concentration in the atmosphere and on the period of fumigation, so that in general a small dosage of a fumigant acting for a long time will be as effective as a large dosage acting for a short time.

Certain fumigants such as chloropicrin, sulphur dioxide and ethylene oxide destroy the germination capacity of many seeds. Most other fumigants, including hydrocyanic acid gas and carbon disulphide, adversely affect the germination capacity of moist grain, but have little or no injurious effect on thoroughly dried grain or other seeds.

Fumigants

The ideal fumigant should be cheap, effective, readily available, have good powers of penetration and diffusion, and be easily removable from the fumigated product by aeration. It should not form poisonous compounds with the substances fumigated. The quality of the fumigated material for purposes of consumption should not be impaired, nor the germination capacity of seeds injured.

Fumigants may be broadly classified into two groups. The first includes those which are gases at ordinary temperatures, obtainable as liquids under pressure in steel cylinders, adsorbed on inert carriers or as compounds which evolve the gas under suitable conditions. The second group includes those which are liquids at ordinary temperatures. Fumigants of the first group include hydrocyanic acid gas, ethylene oxide, methyl bromide and others, and are used largely in atmospheric and vacuum fumigation chambers and for the large-scale fumigation of ships and barges, flour mills, warehouses and other buildings. Fumigants of the second group include carbon disulphide, carbon tetrachloride, ethylene dichloride and others and are used for the small-scale fumigation of store-rooms and storage bins.

Hydrocyanic Acid Gas

There is probably no fumigant known which is as effective for the destruction of insect pests and vermin as hydrocyanic acid gas. It is a relatively cheap fumigant, extremely effective and readily available, and is easily removed from the fumigated product by aeration. It does not normally form poisonous compounds with the material fumigated, and the germination capacity of thoroughly dried seeds is not impaired. Other advantages of hydrocyanic acid gas are that its use is attended by no fire hazard or risk of explosion. On the other hand it is a lighter-than-air gas and has rather poor powers of penetration, which make it unsuitable for the fumigation of some types of stored produce. The risks attending the use of hydrocyanic acid gas are due to its extreme toxicity to man. This danger cannot be too much emphasised, and fumigators should be provided with gas masks fitted with the appropriate canisters for protection against this gas. On account of its extreme danger, hydrocyanic acid gas should only be handled by an experienced fumigator, and is therefore not recommended for the fumigation of grain and other stored produce in small store-rooms and storage bins, unless the treatment is carried out under technical supervision.

Hydrocyanic acid gas for the fumigation of stored produce may be conveniently obtained in the following ways: (1) by generating it in a barrel or other receptacle from sodium cyanide and sulphuric acid, (2) by pumping it into the building to be fumigated as a liquid under pressure from steel cylinders, (3) by spreading on the floor of the building an inert material on which liquid hydrocyanic acid is adsorbed, and (4) by spreading on the floor of the building calcium cyanide in the form of a fine powder, which combines with the moisture in the atmosphere to liberate hydrocyanic acid gas.

In the pot method of generating hydrocyanic acid gas, water is first poured into the barrel or other vessel used as the generator and then the sulphuric acid is added. The correct quantity of sodium cyanide is then weighed out, wrapped for preference in paper or sacking, and lowered carefully into the acid in the generator. Hydrocyanic acid gas is liberated as soon as the sodium cyanide comes in contact with the acid. An adequate dosage for the general purpose fumigation of buildings is 1 pound of sodium cyanide per 1,000 cubic feet of space. Increased dosages, depending on the absorptive capacity of the material fumigated, are necessary for the effective fumigation of different types of stored produce.

Hydrocyanic acid gas may be obtained as a liquid under pressure in steel cylinders. It is a colourless liquid with a boiling point of 79.7°F. In this form it is used extensively for the large-scale fumigation of ships and barges, flour mills, warehouses and other buildings, and in specially constructed atmospheric and vacuum fumigation chambers. The normal dosage of liquid hydrocyanic acid is 8 ounces per 1,000 cubic feet of space, but this dosage may be increased to as much as 1½ pounds per 1,000 cubic feet for certain types of stored produce such as baled cotton and tobacco. The length of exposure to the gas should be from 24 to 36 hours in atmospheric fumigation and from 2 to 3 hours in vacuum fumigation.

Hydrocyanic acid gas is also obtainable adsorbed on an inert material, as in such proprietary products as Zyklon B and Zyklon discoids. These consist of liquid hydrocyanic acid adsorbed on kieselguhr as inert carrier, together with chemical stabilizers, as well as irritant and lachrymatory substances, which give warning of the presence of traces of the gas. Zyklon B and Zyklon discoids are obtained in sealed canisters, and the method of application is by sprinkling the material or scattering the discoids on the floor of the building to be fumigated.

Calcium cyanide is obtainable as the proprietary product Cyanogas in the form of a powder made in various granulations. Cyanogas G-fumigant is a crude granular form of calcium cyanide, and is used for the fumigation of flour mills, warehouses and other buildings and for grain fumigation. The powder is spread on the floor of the building and combines with the atmospheric

moisture to liberate hydrocyanic acid gas. The dosage recommended for general purpose fumigation of buildings is 4 pounds of Cyanogas G-fumigant per 1,000 cubic feet of space. In the large-scale fumigation of grain at terminal elevators, the Cyanogas G-fumigant is fed directly into the grain stream by means of special gravity-feed applicators. The dosage recommended for grain fumigation is 20 pounds of Cyanogas G-fumigant per 1,000 cubic feet (778 Imperial bushels), and this is adequate for other types of stored produce.

Ethylene Oxide

Ethylene oxide is a gas at ordinary temperatures, but is obtainable as a liquid under pressure in steel cylinders. Liquid ethylene oxide is colourless with a boiling point of about 56.3°F. The concentrated gas is inflammable, but at concentrations normally used in fumigation there is little fire hazard and no risk of explosion. Although extremely toxic to insects, the gas is not highly toxic to man and can be used without danger, but the use of a gas mask is recommended to avoid breathing a high concentration of the gas, which causes cyanosis when inhaled for an extended period. Seeds should not be fumigated with ethylene oxide, as their germination capacity is destroyed. When used alone ethylene oxide is applied at the rate of 2 to 3 pounds per 1,000 cubic feet of space.

Ethylene oxide is almost invariably used mixed with carbon dioxide. The addition of carbon dioxide increases the insecticidal action of the mixture, decreases absorption of the gas by the material fumigated and eliminates any fire hazard. This mixture can be made by pouring the liquid ethylene oxide directly onto crushed solid carbon dioxide. The mixture is then stirred thoroughly and introduced directly into the grain or other stored produce. A mixture of 3 pounds of liquid ethylene oxide and 30 pounds of solid carbon dioxide per 1,000 cubic feet (778 Imperial bushels) is an effective dosage for the fumigation of stored produce.

It is very much more convenient, however, to use mixtures of ethylene oxide and carbon dioxide put up in steel cylinders, and a number of these mixtures are on the market. Carboxide is a proprietary product consisting of 1 part of ethylene oxide to 9 parts of carbon dioxide. Etox and T-gas are similar proprietary products containing 1 part of ethylene oxide to 10 parts of carbon dioxide. The method of application of the ethylene oxide-carbon dioxide mixture is exceedingly simple. When the valve on the cylinder is opened the pressure of the liquified carbon dioxide discharges the contents of the cylinder in the form of a fine mist, which volatilizes immediately. A dosage of 33 pounds of this mixture per 1,000 cubic feet (778 Imperial bushels) is effective for the fumigation of stored produce.

Chloropicrin

Chloropicrin has been used to some extent as a lachrymatory gas, and finds some application as a fumigant for grain and other stored produce. It is a nearly colourless or slightly yellowish liquid with a boiling point of 233.6°F., and on exposure to air volatilizes slowly to form a heavier-than-air vapour that is extremely toxic to insects. The vapour is also extremely toxic to man, causing lachrymation and vomiting and produces severe irritation of the eyes and lungs, and it is essential for fumigators to use gas masks equipped with canisters which afford protection against this gas. Chloropicrin has remarkably good powers of diffusion and penetration; but there are a number of disadvantages attending the use of this gas as a fumigant. These are that it tends to be retained by the products fumigated and a considerable period is required for aeration, and that it adversely affects the germination capacity of seeds. Chloropicrin vapour is neither inflammable nor explosive when used under ordinary fumigation conditions.

The usual method of applying this fumigant is to sprinkle the liquid directly onto the product to be fumigated. The low volatility of chloropicrin may be partly overcome by applying the liquid in the form of a spray or fine mist by means of an atomizer or by using a mixture of equal parts of chloropicrin and carbon tetrachloride. Chloropicrin is sometimes used for grain fumigation in terminal elevators, the fumigant being applied directly to the grain stream from a special applicator. A dosage of 2 to 5 pounds of chloropicrin per 1,000 cubic feet (788 Imperial bushels) is recommended for grain fumigation.

Ethylene Dichloride

Ethylene dichloride is a colourless liquid with a boiling point of 183.2° F., which on exposure to air volatilizes to form a heavier-than-air vapour that is toxic to insects. Ethylene dichloride vapour has an anaesthetic effect on man, and a gas mask should be worn if the fumigator is exposed to high concentrations of the gas for an extended period. The vapour is somewhat inflammable, and this fumigant is therefore often used mixed with carbon tetrachloride to reduce the fire hazard. A mixture of 3 parts of ethylene dichloride to 1 part of carbon tetrachloride is recommended.

As this ethylene dichloride - carbon tetrachloride mixture has a rather low volatility, the most satisfactory method of applying the fumigant is by spraying the liquid uniformly over the surface of the grain or other stored produce. A dosage of 15 pounds of this mixture per 1,000 cubic feet of space gives satisfactory results. For grain and other stored produce the recommended dosage is 60 pounds of the mixture per 1,000 cubic feet (778 Imperial bushels). The fumigant is freely absorbed by materials with a high fat-content, and the dosage should be increased for such pro-

ducts. A distinct advantage of this fumigant is that it has no adverse effect on the germination capacity of seeds, regardless of the concentration at which it is used, the length of exposure and the moisture content of the seeds.

Recently a much more toxic mixture has come into use for the fumigation of grain and other stored produce. This consists of the ethylene dichloride-carbon tetrachloride mixture in the proportions given above with the addition of 10 per cent. by volume of methyl bromide. A dosage of 20 pounds of this mixture has been found to be as effective as a 60 pounds dosage of the mixture without methyl bromide. On account of the danger of using methyl bromide, which causes severe irritation of the lungs, this mixture should be applied with extreme care and a gas mask used with a canister affording protection against this gas.

Carbon Disulphide

Carbon disulphide is probably the most satisfactory fumigant for the destruction on a small scale of weevils and other insect pests infesting grain and other stored produce. It is a colourless volatile, inflammable liquid with a boiling point of 114.8°F., volatilizing on exposure to air to form a heavier-than-air vapour that is highly toxic to insects.

The greatest disadvantage attending the use of carbon disulphide is due to its inflammability and to the fact that its vapour forms a highly explosive mixture with air. It is unsuitable for the fumigation of large buildings, but can be recommended for the fumigation of small store-rooms and storage bins, where the fire hazard can be controlled. It is important to realise that an explosion can be caused not only by a naked light, but also by sparks from an electric switch or from metal striking metal, and even by excessive heat and by static and frictional electricity.

Carbon disulphide is considered a comparatively safe fumigant in the hands of the worker with little technical experience of fumigation, provided he is prepared to take simple precautions in controlling the fire hazard and in avoiding the risk of explosion. The breathing of carbon disulphide vapour in excess induces a feeling of giddiness, and as little of the fumigant as possible should be inhaled. The vapour is poisonous if breathed for an extended period, and it is dangerous for persons with weak hearts to take part in fumigation.

The usual method of application of carbon disulphide is to pour the liquid into a shallow dish or pan, or onto some absorbent material such as a wad of cotton wool, placed on top of the grain or other produce to be fumigated. There is no objection to the fumigant being poured or sprinkled evenly over the surface of the produce, and this method is preferable when large quantities of liquid are used. If the depth of the stored produce is more than about 4 or 5 feet, it is advisable to introduce the fumigant to below this depth by means of a pipe, perforated by small openings at frequent intervals along its length. The top 4 or 5 feet of the material will absorb most of the fumigant, unless an excessive dosage is applied, and this device ensures that a toxic concentration of vapour will reach the bottom of the store-room or storage bin.

The dosage of carbon disulphide depends on the quantity of grain or other stored produce to be fumigated, the absorptive capacity of the material and the degree of gas-tightness of the store-room or storage bin used for the fumigation. For the general purpose fumigation of grain and other stored produce a dosage of 30 pounds of carbon disulphide per 1,000 cubic feet (778 Imperial bushels) is recommended. This is a reasonably heavy dosage, but as the produce fumigated is valuable and the fumigant relatively cheap, it is preferable to apply a heavier dosage than is actually necessary. This ensures effective fumigation, in spite of absorption by the material fumigated and slight loss of vapour, due to imperfect gas-tightness of the store-room or storage bin. For the fumigation of empty store-rooms and storage bins a dosage of 10 pounds of carbon disulphide per 1,000 cubic feet is adequate.

The period of fumigation should be from 24 to 48 hours, 24 hours being a sufficient length of time for the dosage recommended above. Fumigation should be carried out preferably at temperatures above 70° to 75° F., optimum results being obtained at temperatures from 80° to 95° F. Carbon disulphide injures the germination capacity of moist seeds, and, if the material fumigated is required for planting, it should be thoroughly dried before fumigation.

Due to the inflammability of its vapour, carbon disulphide is often used mixed with carbon tetrachloride to reduce the fire hazard. Carbon disulphide-carbon tetrachloride mixtures usually consist of approximately 20 per cent. of carbon disulphide and 80 per cent. of carbon tetrachloride. Such mixtures when properly prepared appear to be relatively free from fire hazard. Small quantities of sulphur dioxide may also be added, but the effectiveness of such mixtures is directly proportional to the quantity of carbon disulphide present. For grain and other stored produce the dosage recommended is 60 to 100 pounds of the mixture per 1,000 cubic feet (778 Imperial bushels), application being made in the same way as for carbon disulphide alone.

Whenever practical, the material fumigated should be aired after treatment. Aeration should be carried out for preference in the open air, when a strong wind is blowing. This should occupy the shortest possible time, about 2 to 3 hours being adequate, to reduce the chance of re-infestation of the material by insect pests. The use of an electric fan to assist in aeration must be avoided, on account of the danger of explosion caused by sparking of the motor. Aeration is especially desirable when seeds required for planting are fumigated, as the chance of adversely affecting the germination capacity is thereby reduced.

Carbon Tetrachloride

Carbon tetrachloride is a colourless liquid with a boiling point of 170.2° F., volatilizing slowly on exposure to air to form a heavier-than-air vapour, which is non-inflammable and non-explosive. It is not very effective when used alone as a fumigant against insects infesting stored produce, and is not recommended for use if other fumigants are available. To be at all effective, it must be used at temperatures exceeding 75° F., and at the rate of at least 30 pounds per 1,000 cubic feet of space. The method of application is to pour the liquid into a shallow dish or pan on top of the material to be fumigated. Carbon tetrachloride vapour has an anaesthetic effect on man, and it is not considered safe to inhale a strong concentration of the gas for an extended period. Carbon tetrachloride finds most application in admixture with more toxic fumigants, such as ethylene dichloride and carbon disulphide, to reduce the fire hazard.

Methyl Bromide

Methyl bromide is a gas at ordinary temperatures, but is obtainable as a liquid under pressure in steel cylinders. Liquid methyl bromide is colourless with a boiling point of 40.1° F. The vapour is non-inflammable and is extremely toxic to insects, comparing favourably in toxicity with hydrocyanic acid gas, ethylene oxide and chloropicrin. Methyl bromide vapour is dangerous if inhaled by man and severe lung irritation follows exposure to the gas. On account of this danger, extreme care should be exercized in using methyl bromide, and a gas mask worn with a canister affording protection against this gas. Methyl bromide is well suited for the fumigation of dried fruits, and for this purpose, as well as for the fumigation of grain and other stored produce, a dosage of 1 pound of methyl bromide per 1,000 cubic feet (778 Imperial bushels) is adequate to give an effective kill of infesting insects. Methyl bromide also finds application in admixture with other fumigants, such as ethylene dichloride-carbon tetrachloride mixtures, to increase their toxicity.

Other Fumigants

There are a number of chemicals, such as phosgene, sulphur dioxide, trichlorethylene, orthodichlorbenzene and others, which have been used with some success for the fumigation of insect pests in stored produce. The use of many of these is limited by inferior toxicity, dangerous and insidious effects on man, excessive absorption of the fumigant by the material fumigated, and other undesirable characteristics.

Acknowledgments

In the compilation of this paper use has been made of numerous publications on fumigation, including contributions to various scientific journals and publications of the Department of Scientific and Industrial Research, London and the United States Department of Agriculture, Washington, D.C., to which grateful acknowledgment is made.

METHODS FOR STUDYING MANURIAL NEEDS OF SOILS

(The following note is abridged from an article entitled "Laboratory, Greenhouse and Field Methods of Studying Fertilizer Needs of Orchard Soils", by R. E. Stephenson and C. E. Schuster of the Oregon Agricultural Experiment Station, U.S.A., which was published in "Soil Science", Vol. 52, pp. 137–153, 1941.—EDITOR.)

THE data obtained for typical areas of orchard land in Oregon and reported in the original article, indicate that the better soils contain more easily soluble plant nutrients than the poorer soils. Such reliability as rapid chemical methods may possess, undoubtedly rests upon this fact. *A good supply of essential nutrients is not sufficient, however, to assure satisfactory production in nut orchards: the physical character of the root zone and of the soil profile is equally important.* Physical properties are important because of their relation to root development and the proper functioning of the roots. Compact subsoils and claypans may limit soil depth as effectively as bedrock. It is evident that no system of soil fertilisation, however adequate the supply of plant nutrients may be, is able to counteract a bad physical condition, such as a compact subsoil or lack of depth. The first requisite to the successful use of fertilizers is a soil whose physical properties adapt it to the needs of the crop that is to be grown. Availability of nutrients to plants is contingent upon the presence of roots, and also upon the ability of the roots to function in absorbing those nutrients. It has recently been shown that roots, although present in a soil, may be unable to function after a waterlogged condition has developed. Roots occurring in a waterlogged soil containing an abundance of moisture may fail to absorb sufficient moisture to meet the needs of transpiration.

Even in good soils, most of the nutrients required by the growing plant apparently come from the surface layers. The deep soil serves principally to supply moisture through the deeper parts of the root system. Shallow-rooted crops therefore may thrive on wet soils if there is moisture in the upper portion during the growing season. Deep-rooted plants that produce their

crops during months of dry weather are entirely dependent upon stored soil moisture. Probably eight or ten feet of soil are necessary to allow sufficient soil volume and moisture storage, since only storage in the root zone is of much help to the plant.

When plants are grown in the greenhouse on samples of soil taken at different depths, the best growth is obtained in samples taken from the surface two or three feet of the profile. Below this depth, the amount of growth gradually diminishes. It is noticeable also that the surface horizons of the profile are more responsive to nutrient additions. Soil from the deeper layers may show a large percentage increase, but total growth may be small.

The efficiency of compost and other organic materials for correcting nutrient deficiencies in the soil indicates the importance of providing for adequate humus renewal. Annual cover-crops, stable manure, waste hay and compost may all be utilized for soil improvement, although *no system of manuring or orchard management appears to offer compensation for lack of depth and aeration of the soil.* The physical nature of the soil profile is just as important as its chemical composition. When the soil is physically suited to deep-rooted orchard crops, the adequacy of the system of manuring practised becomes important.

Only long-time trials in the field, extending through at least several years of the life of an orchard, can definitely determine the responses from fertilisers used under field conditions. The use of the physiologically-acid fertilisers, such as "Ammophos" and sulphate of ammonia gives excellent results for a time. But the effect after several years, when a gradual accumulating acidity attains injurious proportions in the soil, may be very serious. Probably liming will become necessary to correct the acidity.

There appears to be a definite advantage in using small portions rather than a larger bulk of the soil for greenhouse studies. With little soil and liberal use of all nutrients except one, the growing plant easily exhausts the supply of the one nutrient which must be obtained entirely from the soil. This procedure makes it possible to accentuate deficiencies in such a way that the relative seriousness of the deficiency may be estimated. This method measures the nutrient-supplying ability of the soil for the individual nutrient with any particular plant.

There is also an advantage in using small field-plots in that they allow many replications and eliminate, to some extent, the difficulty of dealing with soil variability. Responses are as definite on an area of 100 square feet as on an acre. *Unless the treatments double the yields, the responses from fertilisers are probably of little actual significance.* The expense of field trials is greatly reduced by using small plots that may easily be continued or abandoned according to circumstances. This type of work is largely exploratory in nature, and its results may be used in ultimately setting up more permanent long-time trials that may be carried out on a larger scale.

SUMMARY

(1) Rapid chemical tests for measuring available plant nutrients in the soil that may serve as a basis for a fertiliser recommendation have only a limited value for cover-crop fertilisation in orchards.

(2) Greenhouse trials on small soil samples in pots are more valuable than chemical tests. Greenhouse trials require only 6 to 10 weeks, and they give quite definite information as to soil deficiencies for any particular plant. The sunflower has proved to be a good indicator plant for greenhouse studies.

(3) In field trials, orchard cover crops are affected by deficiencies of those elements found to be most deficient by greenhouse pot tests using sunflower as indicator. Miniature field plots may be very helpful in obtaining data which may tentatively serve as a basis for fertiliser recommendations.

(4) No type of study which fails to give adequate consideration to the physical properties of the soil should be considered a proper basis for orchard soil management.

(5) It is concluded that orchard soils should be first subjected to physical and chemical studies, particularly relating to the depth, capillary porosity, and noncapillary porosity, and to the aeration throughout a 10-feet profile.

(6) Physical and chemical studies should be accompanied by greenhouse trials in order to establish major and minor soil deficiencies. These should then be followed by extended trials in the field by means of which the cumulative effects of various fertilisers over a period of years may finally be established.

THE ROOTSTOCK QUESTION IN CACAO

In pointing out the need for the improvement of cacao in Java it is suggested in an article published in *Bergcultures*, XV, 553–6, that the Angoleta, Djatiroenggo and Forastero hybrids show such marked variations as to afford great opportunities for the selectionist. A study of the question of rootstocks is particularly important. An instance is quoted and supported by photographs of the good growth and yield made by Angoleta hybrids of Forastero rootstocks, whereas on their own roots under comparable conditions they were weedy and unprofitable. They were also considerable differences in vigour between various Forastero families of similar age. When these were budded (in this case with white cotyledoned Djatiroenggo clones) a clear correlation was found between vigour of stock and vigour of the resulting budded tree.

THE CACAO INDUSTRY OF BRAZIL *

BRAZIL exceeds all other Latin America countries by far in the exportation of cacao. The exportation of 134,172 tons in 1936 was the largest to date†, in the history of the country, and was exceeded in world export only by the Gold Coast of Africa which exported in the same year 338,386 tons. (Since relatively small amounts of cacao are consumed in Brazil and the Gold Coast, export figures and production figures are practically the same.)

Cacao grows wild in several regions of Brazil where natural conditions are favourable. Its commercial production is generally confined to the states of Amazonas of the Upper Amazon Basin, in Para' and Piaui' of the Lower Amazon Basin and to several selected areas on the coastal lowlands of eastern Bahia.

Lower Amazon Region

In the earlier part of the nineteenth century many cacao plantations were established on the banks of the Amazon river and its main tributaries. From 1852 to 1862 the average annual export was 3,076 tons. For a time increase was slow, then rapid to 1888, the banner year, when 9,000 tons was exported. With increasing yields and favourable prices, the plantation owners expected to continue to dominate the market without much effort on their part. Production remained steady with slight variations from 1888 to 1915 but 1915 to 1918 the average annual export fell to only 3,704 tons, not much more than it had been sixty years before. Since then the exports have continued to decrease until they have well-nigh become negligible.

The present outlook for the industry within this region is not bright. Most of the plantations are from seventy to eighty-five years old and few new plantings are being made. The decline of the Lower Amazon industry has resulted partly from (1) ravages of insect pests, (2) frequent floods over relatively low-lying plantations, (3) lack of pruning, (4) thick stands of trees, and (5) neglect to provide shade and wind-breaks. Some of the causes are attributed to the lack of an adequate labour supply and careless production practices. An additional reason for the decline of the cacao industry in the Amazon Basin has been the competition afforded by the same industry in the state of Bahia. By 1895 the exports of cacao from that state surpassed those from the Amazon Basin and since that time the production of Bahian cacao has increased to relatively large proportions.

Region of Eastern Bahia

The Bahia cacao region is located in the eastern and south-eastern parts of the coastal lowland of Bahia in eastern Brazil in separate and distinct areas not far from the sea, it extends approximately from Rio Jequirica to the boundary of Espirito Santo, the state south of Bahia, and is about 360 miles long and from 10 to 100 miles wide (Fig. 1). In the region are planted about 110,000,000 trees on 500,000 acres of land, averaging 220 trees to the acre. The plantations are not regularly distributed, but are grouped

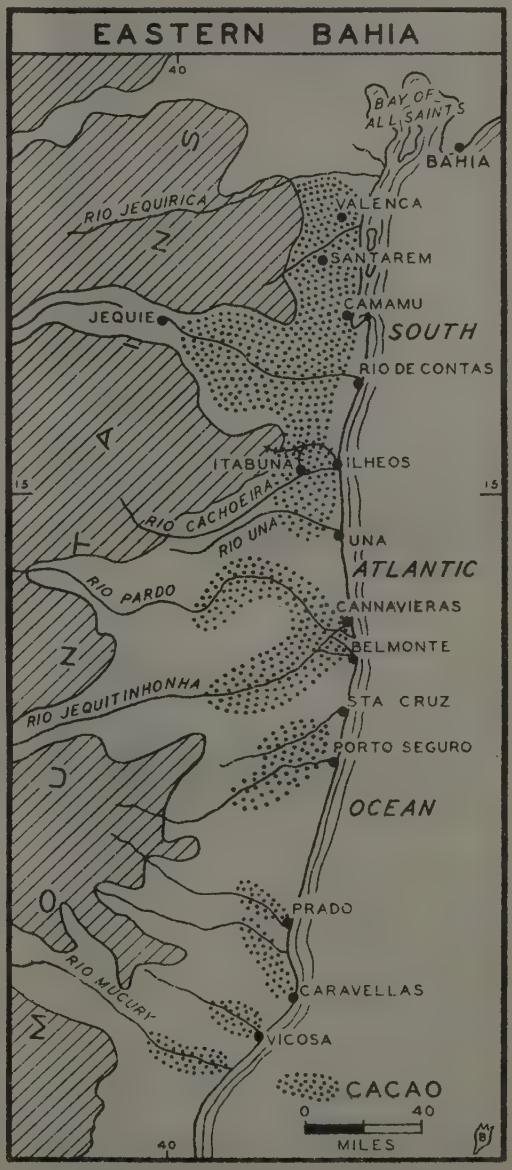

FIG. 1—Cacao and Physical Map of Eastern Bahia, Brazil.

* Article by E. Keithan reprinted from *Economic Geography*, Vol. 15, pp. 195-204. † 1939.

about centres, sometimes separated by long stretches of virgin forest, while others continue without interruption over large districts. The producing centres may be divided into three groups ; the first from the river Jequirica to the river Una, includes the important centres of Jequi, Rio Contas, and Ilheos, the largest of the districts ; the second is situated on the banks of the rivers Jequitinhonha and Pardo ; the third is formed of more or less isolated plantations southward. A river and its tributaries always form the centre of distribution of the plantations.

In the first group the plantations are found on the banks of the rivers and numerous other streams, on the hills, on their slopes, in the intermediate valleys—in short wherever the cacao tree thrives. In the second group, the plantations lie on banks of the rivers on rich alluvial plains, often inundated by high floods, for which reason new plantations are being laid out on higher ground. The third group, the newest of them all, shares in some degree the features of the first two. The difference between the first two groups is shown in the quality of the product. The cacao coming from Belmonte and Cannavieiras, of the second group, is better prepared and of better quality. In the Jequitinhonha centre are found the best equipment and best cultivated plantations. The first group, although it produces good cacao and has good plantations, is divided into smaller farms under numerous proprietors who cannot, because of shortage of labour, give the product the care it requires. This group, in which are Ilheos, Rio de Contas, Jequi, Santarem, Camamu, and Una, supplies almost 76 per cent. of the total output of the state.

The cacao region of Bahia extending from about 13 degrees to 18 degrees south latitude, is characterized by regular rains, even temperatures, humid atmosphere, presence of tropical forest and soils rich in humus or fertilizing matter. Over so large an area, the conditions certainly vary somewhat, but on the whole they are not noticeably different. Plantations occupy low hills not over 1,000 feet in altitude in the north, and levees of rivers at a much lower elevation in the south. The cacao tree produces at greatest altitudes in this region, but the transport of the crop is more difficult and since there is plenty of land available at lower levels, upper slopes will likely be utilized for further extensions of the plantations.

The region is characterized by rainy, low-latitude types of climate. Full climatological data are almost lacking except for two stations, Ilheos, located almost within the heart of the region, and Salvador (Bahia), the capital city, 120 miles to the north. The average annual temperature for Ilheos from 1909 to 1919 was 76.4°F. and the average rainfall for 1912 to 1919 was 88.8 inches. Relative humidity for one year was 87.9 per cent. The prevailing winds are east. The average temperature of Salvador (Bahia), was 77°F. with an annual rainfall of 80 inches, with a high relative humidity and prevailing easterly winds.

For the region in general the average temperature is estimated to be from 77°F. to 81°F., the maximum 91°F. and the minimum 56°F. Temperature of 91°F. is recorded on a sunny day, followed by a drop to 65°F. the next morning.

The annual rainfall averages from 70 to 80 inches and more, and there is rain every month. Some months are considerably rainier than others and it is in these rainier months that the cacao grows rapidly, provided there is sufficient sunshine. At Ilheos it may be said that the rainiest months are from January to May and the cloudiest and coolest months are June to September.

The relative humidity of the atmosphere is usually high. During the night and early hours of the day, fog may cover the valleys, the savannahs, and even the hills.

The east coast of Bahia has easterly winds in all seasons, southeast in July and east and northeast in January, when there is a monsoonal inflow to the heated interior. Since most of the showers are of the convectional type, the winds have little to do with their occurrence, but they affect the temperatures, especially near the coast making the region somewhat more pleasant for residence. Uniform temperatures accompanied by heavy rainfall, together with periods of bright sunshine and gentle winds, combine to make the region one of the best cacao regions of Latin America—and of the world.

The soils where the cacao is planted are usually good, rich in plant nutrients. The area was formerly covered by dense tropical forest. Analyses have not been made and so the composition of the soil is not known. On the banks of the rivers, in the plains, and in the deep valleys between the hills, soils are high in humus formed from deep beds of decomposing vegetable matter. Most of the plantations are laid out upon the commoner sandy loams and clay soils. On the slopes of the hills, fertile clay soils excellent for cacao, are formed from the decomposed native rock. Numerous plantations on such soils distinguish the vicinity of Ilheos. At Belmonte and Cannavieiras the predominating soil is alluvial, rich in humus, on the banks of the rivers. In the other producing centres good alluvial soils are found but residual soils are most widespread.

With the exception of Cannavieiras and Belmonte, where soils are better chosen and prove more fertile, planting is done without much regard to the conditions of the soil. On sandy soil, in places where compact rock is present, or where water accumulates and forms permanent marshes no planting is done. With this careful procedure good crops have been obtained so far. The average production is much lower when poor soils are chosen for planting. There is no need for such choice for there is still much fertile land unused.

About nine-tenths of Bahia cacao plantations are found on the higher or sloping land and about one-tenth on the low plains bordering the Pardo, Jequitinhonha and Mercury rivers. The distribution coincides with the stream pattern and insures to most of the plantations adequate drainage. Added to this natural drainage the permeable soils with a minimum of silica and sufficient amount of clay to hold water in time of rains for periods when little rain falls increase the advantages for cacao production.

The cacao industry is the largest and most important industry in Bahia, for although there are no official statistics, it is estimated that over 750,000 people derive their income from it, folk directly or indirectly connected with the industry, engaged either in its commercial aspects or else interested in its agricultural phases. The population density in this region is estimated to be from thirty to sixty people per square mile, composed of Indians, Europeans, and Negroes.

The region has shown for many years a distinct adaptability for the production of cacao, yet the industry dates only from the later years of the nineteenth century. Prior to the 1880's most of the present cacao area remained virgin wilderness. When the emancipated slaves from the northeast sugar districts of Brazil migrated, in 1888, to the region, they formed an increased and steady supply of local labour for carrying on the industry. The natives and their descendants are now living mostly on the plantations, large and small, in their own huts or in others provided for them by the owners.

There are no available statistics as to the proportion of population engaged in any particular phase of the industry. There is reason to believe, however, that the number employed is fairly constant and sufficient, except at harvest time, when additional labour and supervision to harvest and market the product are provided by crowds of travelling labourers from the north who work their way south to the coffee plantations in Sao Paulo. Some are secured also from neighbouring villages and towns.

Some planters live on the cacao plantations for all or part of the year, but the greater number of owners live in the larger towns, in Bahia or abroad. The cacao merchants who are interested in the exporting phases reside largely in the cacao centres in or near the coast. They make up a large part of the population engaged in the industry.

The transportation pattern of the cacao industry is, for the most part, coincident with the stream pattern of the areas in which cacao is produced. Most of the cacao is raised within 75 to 100 miles of the coast and usually in close proximity to river transportation. Except for a few miles of rail and motor roads serving the districts of Ilheos and Carvallas, water provides transport for almost all the cacao that reaches the coast.

A large part of the product is carried by native labourers and by pack-mules, from the plantations to the nearest river, at considerable expense and here it is transferred to canoes for transport to the nearest ports along the coast. The small cacao-port centres are served by Bahian coastwise ships, schooners and launches which transport the cacao either to Ilheos or Salvador (Bahia), the leading cacao seaports of the state.

History and Trends of the Industry

Cultivation of cacao in Bahia is said to have begun in 1746, from seed brought from Para' by the French planter Louis Frederic Warneaux. The seed was sown on the right banks of the river Pardo in the county of Cannavieiras by Antonia Dias Ribero. The Portuguese government took an interest in the cultivation and tried to assist in production through its agents, who were designated "Conservers of the Forests".

The tree soon became well known and is occasionally referred to in the records and writings of the period. But that cacao had all but faded from the thoughts and occupations of the Bahians is indicated in the works of the great German botanist, Martins, who when visiting southern Bahia in 1819 wrote as follows: "This culture had a very happy beginning, but actually there remains scarcely a vestige of it in the maritime villages, and it was only at Camamu that a few trees were encountered, and their luxuriant aspects demonstrates beyond a doubt their ready adaptation to the region".

About 1818 Pierre Weyll and his companion, Sanaraker, obtaining a grant of land in eastern Bahia from the King, on two occasions brought German planters to colonize this land. At that time people were interested in the cultivation of sugar cane, coffee, and tobacco but the cacao tree was also planted. Old cacao trees of these first plantations by the Germans formed the nucleus of the industry of Ilheos. In 1778 the export of cacao from Bahia was about 2,000 pounds; cultivation developed slowly and in 1835 the export reached about 59,000 pounds.

The second German colony was established on the Rio Cannavieiras, and by 1852 the plantations had become prosperous. The culture spread to Belmonte, Rio Contas, and Valenca, in fact to the whole southern Littoral. In 1868 exports had amounted to 815 tons, largely as a consequence of the influx of emancipated slaves from the sugar districts to the north, of the adaptability of the region to cacao, as previously mentioned, and of high prices paid for it at the time. Statistics show the amount of exports of cacao from Bahia to have increased yearly, from an insignificant place to a position of price importance in the industry of the state. The attainment of this position is attributed not only to the adaptability of the tree to the region but also to the phenomenal increase in the consumption of cacao throughout the world during the first quarter of the present century.

Though there appears no reason to suppose that cacao production in Bahia will not continue to increase, the industry labours under a number of handicaps, such as high export and municipal taxes, heavy transportation charges, and sometimes scarcity and costliness of labour. Because there are not enough permanent workers on the plantations to harvest the crop, as already stated, planters must rely on casual labour at harvest time. Such labour is generally of mixed Indian and Negro type and is not highly competent. It must be paid in cash which is generally secured on credit against contracts to deliver cacao, a system which naturally tends to depress the price the grower receives for his product.

Planters have agitated considerably for some sort of government protection against fluctuations in prices, such as already exists in the coffee trade, but they generally recognize that the obstacles in the way of such a scheme are difficult to surmount chief among them being the fact that cacao cannot be stored for any length of time in a hot, damp climate. Moreover, Brazil does not occupy the same commanding position among the world's cacao growing countries as among the coffee producing countries.

It is claimed that Bahia is ideally situated for the production of cacao and land recently opened up is said to be better suited for cacao production than any to be found in the state. In spite, therefore, of factors militating against the development of the industry, it seems likely that production will continue to increase.

Marketing of the Cacao

The greater portion of the cacao grown in Bahia is exported. What proportion of the crop is marketed abroad is not known but since production figures and export figures are used interchangeably, it is reasonable to believe that it is almost 100 per cent. Home consumption is very small for the natives prefer other beverages to cocoa, and chocolate in the form of candy rarely enters their diet.

In addition to this, cacao constitutes a large share of the total amount of the agricultural exports of this region. Statistics show that this product constitutes over 80 per cent. of the total value of exports. The importance of cacao is relatively greater than the export figures indicate, because of the number of people who are dependent on one phase or another of the industry.

The dependence on cacao is emphasized by the fact that the majority of the cacao planters are natives who reside in the region, spend their incomes there, and for the most part employ native labour. If the crop to which they look for their cash income is good and the price of cacao is high, those interested in the industry directly or indirectly prosper; but if the crop is poor or the price is low, business is depressed and those interested in the industry suffer. In addition, marketing methods have much to do with the success of the industry in each region. Careful and clean methods of disposition of the crop have a distinct effect upon the material well-being of those connected with it. If the methods are careless and unsanitary, results in decreased exports quickly become apparent and business is affected accordingly.

Financing the Crop

The objectives of the association organized for the purpose of advancing money to cacao planters in Bahia include aid in planting, cultivating, grading, and marketing the crop. Here the Cacao Institute of Bahia was established in June, 1931, to regulate and improve production, grading, and marketing of cacao beans. Up to the present, the chief activities of the Institute have been to finance production and marketing. So far, nothing but propaganda and advice have been given to improve methods of production and grading has been left to the local exporters. The Institute appoints inspectors to supervise grading and gives certificates to interested persons. It has been advancing money to planters, up to 70 per cent. of the market value of the cacao beans consigned to it. The money is derived from a $1,050,000 issue of bonds for this purpose. The Institute exports the cacao beans thus consigned to it and purchases for other local dealers.

Selling Price and Demand

Until recently Bahia received fair to good prices for cacao. As early as 1928, however, prices began to show a downward trend. A decreased market on the part of the American buyers, an abortive attempt at cacao valorization, increased export taxes both state and municipal, and considerable losses by a number of export houses in Bahia which indulged in speculative transactions in cacao have led to the decline.

Continuing increased production of ordinary cacao in the regions of West Africa stimulated by increased consumption of such low-grade product in the United States and Europe aggravated the situation. In order to sell their crop the Bahians were forced to reduce their selling price to such a low figure that is barely covered production costs. Had it not been for increased world consumption and the extreme depreciation of the milreis (Brazil's unit of money = 10 cents in United States money) whereby farmers received more milreis for the dollar, the industry would have suffered collapse. The situation shows little tendency to improve unless new factors are introduced to establish a more solid financial basis for the crop.

As has been mentioned before natural conditions for the production of cacao in Bahia are almost ideal. The financial success of the crop, however, depends mainly on the transport, the cost of which must correspond with the market prices of the product. If railways cannot be constructed, roads for transport animals would

be sufficient, provided they are well maintained. Localization of adequate labour is a second requirement to supplant merely casual labour, which by its lack frequently causes wage increase. Finally, government measures to encourage and protect planting by laws giving prizes for good produce, prescribing the construction of roads, decreasing export duty on cacao, facilitating the acquisition of land, founding experimental stations, and instruction by agricultural officers about the producing centres in good methods of intensifying rather than extending cultivation; in short to transform cultivation from the present primitive state to modern scientific method. Once these measures are taken, progress may be expected in the industry. They are necessary if the industry is to withstand a continued low price, a price not likely to be improved in view of increase in the world's production of ordinary cacao.

NOTE.—Most of the statistics used in this article were obtained from *The Gordian*, Vol. XLIII, No. 1031.

ECOLOGY IN AGRICULTURE *

The major emphasis in ecological research, by ecologists, has been on native or wild plants and animals and not on cultivated plants and domesticated animals. Human ecology has also been largely untouched by ecologists. Scientists in other fields such as agronomy, horticulture, pathology, geography, sociology, and economics have not only been making increasing use of ecological concepts and procedures, but have been urging ecologists to broaden the scope of their investigations and teaching, so as to include the whole gamut of life in relation to the environment. The value of men who have been well trained in ecological technique and thinking has been long appreciated in forestry and range management, but now the call for help is coming from numerous additional fields. I am not advocating any diminution of interest and activity by ecologists in native plants and animals. We need to study these organisms under natural conditions much more than we have in the past in order to secure an adequate fund of basic information to use in planning improved relationships of people to the land. A few examples will be described to illustrate the need for ecologists to conduct research in crop plants.

At a recent conference of scientists and representatives of industry to consider ways and means to increase domestic production of flax seed and to improve the quality of the oil, a prominent plant pathologist emphasized the need for a comprehensive study of the ecology of the flax plant. While much research has been done to improve varieties by breeding to control diseases, and to maintain yields by good agronomic practices, only a small start has been made in determining the relationships of the flax plant to the soil and climatic conditions. Since one of the chief hazards in growing flax is its high degree of sensitiveness to changes in environmental conditions and since it is an important crop, not raised in sufficient quantity in the United States to supply the demand, it furnishes excellent material for the ecologist interested in plant-weather-soil relationships. It also furnishes a good opportunity to the ecologist who is interested in contributing to the solution of a serious agricultural and industrial problem by providing basic information about this plant. Other crop plants such as wheat, corn, cotton, sweet clover, and alfalfa provide numerous problems and abundant materials from a wide range of environments. The study in crop-weather relationships that is being sponsored by the Bureau of Agricultural Economics in cooperation with the state experiment stations in Kansas, North Dakota, Ohio, and Iowa, is an example of the ecological method of attack conducted cooperatively.

It is being increasingly recognized that reduction in damage caused by grasshopper infestations must be based on a foundation of ecological knowledge. The difficulties involved in the destruction of grasshoppers, such as the wide expanse of infested territory, the recurrence year after year of serious infestations, and the gigantic migrations such as occurred in the summer of 1938, can be solved only by a broad ecological attack. Poisoning alone is too expensive a method. The ecological foundation that must be erected for fully scientific control measures will be constructed from an assortment of building materials such as life history studies of various species of grasshoppers; interrelations of egg-laying, hatching, and other functions of grasshoppers to soils, vegetation types, and climatic factors; effects of various animals upon grasshoppers, including the requirements for sufficient shelter and nesting sites for birds and other predators of grasshoppers; effects of soil-conserving tillage methods and crop rotations upon egg-laying, egg-destruction, and hatching. Careful ecological study is needed to appraise the value to the farmer of burning weeds and brush in fence rows in relation to the need for shelter for birds and mammals that will prey on grasshoppers. What effect will artificial lakes and ponds, by providing favourable habitats for gulls, have upon control of grasshoppers? Will the reduction of wind erosion by grass buffer strips be offset by providing breeding sites in the strips for grasshoppers, cut-worms, and other insects? Additional

* Abridged version of an address by H. C. Hanson, President of the Ecological Society of America, which was published in *Ecology*, Vol. 20, No. 2, pp. 111-117.

interrelations of grasshopper control are found in overgrazing and regrassing of abandoned plough fields. Serious grasshopper infestations may continue to occur in spite of all that man can do, but the ecologist, through research can point the way towards reduction in frequency and the area of the infestations.

An interesting ecological ramification started for me about ten years ago when I visited the sagebrush-covered Laramie River Valley in northern Colorado. After consultation with ranchers, who needed more spring and fall range, an experiment was started in an attempt to secure more grass by burning the sagebrush. The thin stand of grass under the sagebrush was soon replaced by a phenomenal growth of grasses. In a short time an experiment station circular was issued describing how improvement could be secured in such areas. Satisfaction over the rapidly secured beneficial results of the experiment was soon faced with the objection that there was too much danger in burning sagebrush because such fires might spread to the forest. Further west another objection appeared. Burning of the sagebrush was following by growth of annual weeds which was less desirable than the original stand. The sagebrush could be used to some extent, at least, as emergency forage and would catch the snow drifting with the wind, but the weeds were practically worthless. Additional complications were appearing meantime in Utah, Idaho, and California. Curly top, a virus disease, had been causing heavy losses in sugar beets, beans, and other irrigated crops. Control measures were not effective. It was baffling the plant pathologists until E. D. Ball found that the beet leafhopper was the vector transmitting the disease. Investigations by pathologists, entomologists, and ecologists soon revealed that the beet leaf-hopper builds up its numbers on annual weeds, especially green tansy mustard and Russian thistle, and that sagebrush and grasses are not important as host plants. The annual weeds occur as first invaders and in large numbers on abandoned plough land, overgrazed and burned-over ranges. Under favourable conditions, this first stage in secondary succession is replaced in about five years by downy brome grass which is infested. Burning of downy brome grass, which may accompany burning of sagebrush, delays further succession and favours reappearance of the annual weed stage. So, misuse of range and cultivated land is not only cumulative but far-reaching in its effects, and a practice considered beneficial in one area may have serious unsuspected consequences in another area. Burning of sagebrush and overgrazing may result finally in the distant, irrigated farmer losing his crops of sugar beets and beans.

This story shows the importance, in wise use of our land, of the climax or near-climax stage, with its perennial plants, not only in providing a more stable source of feed for livestock and protection for the soil, but also in for providing protection for irrigated crops from insect infestations. Now when large portions of the western half of the United States are showing the serious, far-reaching consequences of grasshopper infestations, droughts, and various kinds of misuse such as overgrazing, misplaced ploughing, and improper irrigation, the call is becoming more insistent for the ecologist to help in unravelling the intricate inter-relationships involved. Concepts and tools that are needed are methods of achieving harmonious relationships of organisms between themselves and to their environment, the concept of the natural tendency of community development toward stabilization with the environment, and the need for natural areas as checks, or standards, by which the values and effects of tillage, irrigation, drainage, grazing, lumbering, and other uses may be measured.

. . . It is generally recognized that disturbances in the balances, or equilibria, of nature are always serious and require time for the processes of readjustment. The destruction of trees by fire, landslides, or parasites is followed by a series of successional stages that requires many years for the establishment of a new balance. Several generations of plants and animals follow one another in the readjustment processes. Each generation contributes something toward stabilization, such as organic matter to the soil, shade which favours growth of seedlings of the next stage, and increased retention of moisture. One generation of community of organisms usually makes conditions more favourable for the next generation of the same or different species. This process of natural succession, in which man plays no part, is generally recognized as being complicated and gradual. How much more intricate and difficult the processes of readjustment and stabilization become when man himself is involved as the chief dominant species in balance upsets!

. . . It is one of our duties as ecologists to aid in securing a new balance by pointing out, not only how field operations as reforestation or regrassing can be hastened, but also to discover and to teach the ecological processes involved in human adjustment and stabilization.

. . . About 30 to 40 years ago, the fertile, gently rolling lands of north-western North Dakota were homesteaded by hard working farmers who saw opportunities to make a living by tilling the soil. Every encouragement by public and private agencies was given this invasion of the northern Great Plains grassland. The settlers were tillers of the soil, not ranchers or range men. Their mode of living, and their mental attitudes were adjusted to the plough, the harrow, the drill, the waving grain field, the threshing machine, a few livestock, and the farms comprising only 160 or fewer acres. Their mental and physical habits and customs were not adjusted to the necessities of the cowboy and sheep-herder; such as water holes, the wide range, corrals, good riding horses, and the roundup. At first wheat farming was restricted largely to the best land. During the World War much additional land was turned "wrong side up", due to the

encouragement given to increased production of wheat. Many of these fields were located on slopes and on soils not suited to tillage. Since 1930, unfavourable conditions, droughts, wheat rust, insect infestations, and low prices have prevailed. Most of the farmers in this region, as fine a lot of industrious, enterprising people as can be found anywhere, have been reduced to poverty; the majority are now necessarily dependent upon governmental grants for their livelihood; a condition disliked by most of these farmers, but they are caught in the meshes of disturbed equilibria. They have been attempting to establish a relationship to the environment which was based upon, not only inadequate knowledge of this environment but, in some measure, at least, upon a relationship to a more eastern, moisture environment. The farming methods and size of farm, suited to climatic and soil conditions in Iowa and Minnesota, have been demonstrated to be out of adjustment with the Great Plains environment. The years since 1930 have proved the impossibility of securing adjustment of the people to the environment chiefly by use of the plough and the wheat plant. Instead of gradual development of the community towards stabilization, the pioneers have often been making conditions less favourable, rather than more favourable, as should be the case, for the next generation.

Such disturbed equilibria have given occasion for many rash statements, such as the people are coming "grant-minded" or "relief-minded" and the entire area should be planted to grass and returned to wild life or to the Indians as quickly as possible. Such statements show insufficient recognition of the difficulties that even plant pioneers have in establishing themselves. Where conditions are highly variable, as in an active sand-dune area, along a shore-line or in an abandoned field, subject to overgrazing and drought, successive waves of migrants may appear before succession actually gets under way. The first plants to grow in such places may have the sand blown or washed away from under them or be killed by drought, leaving no successors. Ecologists may question whether even the first step in succession, namely, "invasion" has been accomplished under such conditions. Similarly, perhaps it may be questioned if the pioneering homesteaders have actually accomplished "invasion" throughout the region when there is considerable emigration, especially of the children, and abandonment of farms.

. . . Successful "invasion" has, of course, been accomplished in some localities and stabilization is beginning. Attainment by the people of equilibrium with the environment, or the development of a "climax" community, will be a slow process, but the essential steps are being taken. The people realize the need for more thorough knowledge of the environment and of the means for adjusting themselves by their processes and tools to the conditions of the region. This does not mean planting at once all tilled land to grass, but it means making use of all available scientific information in order to adapt their modes of living to the environment. It will probably mean restriction of wheat growing to the best land, more grass, more livestock, increased soil and water conservation, larger farming units, increased feed reserves, increasing aggregation of people into various kinds of groups, improvements in social institutions so they will facilitate further adjustment, and increasing emphasis on the ecological point of view in planning so as to secure greater stability and higher standards of living. This will not be attained quickly, since numerous adjustments are needed in economic, psychological, and social processes and relations, in addition to the simpler physical operations. The ecologist in this case which is typical of many others, realizing the time needed for stabilizing processes, will be patient. He can, also, be very helpful in applying the concepts of his science to promote stabilization in the . . . regions where serious mal-adjustments between the people and their environment occur.

Permanent agriculture must be in adjustment with the environment. The United States is passing from its pioneering stage into more advanced stages. In too many regions, however, pioneering or invasion will be repeated, but it is hoped that it will be based upon a sounder knowledge of the environment. Stabilization of agriculture to the environment requires the services of scientists in many fields. The special contribution of ecology is to ferret out relationships with the environment so that man, using this knowledge in conjunction with that obtained from other fields, can strive intelligently to secure balance and stabilization, a goal essential for the attainment of the "abundant life" and the building of a culture far beyond our present dreams.

VITAMINS IN MOLASSES *

In addition to its energy-giving qualities, molasses has been found to be a rich source of iron and calcium, the minerals commonly lacking in some diets; and also of several vitamins of the B-complex, which are associated in nature with plant carbohydrates. Its iron is mostly in a form readily assimilable by the human body. Even high-vitamin brewer's yeast, widely used in medicine as a concentrate of the vitamin B-complex is preferentially grown on a nutrient rich in molasses from which the yeast can absorb or synthesize biotin, pyridoxin and other minor members of the B.-complex.—(*International Sugar Journal*, Vol. XLIII, p. 379.)

* *Industrial Bulletin* of Arthur D. Little, Inc., No. 171, 1941.

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Modern Knowledge of the Vitamins

"Dr. 1918" knew of three vitamins, fat-soluble A, water-soluble B and the antiscorbutic vitamin C. The amounts in various foods were represented by one or more plus signs. Now the amounts in food and the requirements of human beings can be given quantitatively. As with hormones, the chemist seems suddenly to have mastered the difficulties of isolating vitamins in a pure form and of analysing their structure. The structures of nine have been discovered within the last ten years ; seven have been made artificially ; three and a substitute for a fourth are made on a commercial scale.

The practical importance of this fourth, vitamin K, is a story of the last three years. It has been known since 1934 that the blood of chicks, the food of which did not contain this vitamin, clotted very slowly. The reason for this delay is deficiency of prothrombin—one of the normal constituents of blood plasma which is a factor causing clotting. The amount of this factor in plasma is reduced in liver diseases also, partly because bile, secreted by the liver, is necessary for the absorption of vitamin K, without which men, like chicks, cannot make prothrombin, partly because the diseased liver may not be able to make prothrombin even when sufficient vitamin K is absorbed. Because the blood did not clot, bleeding was one of the dangers of operations on patients with diseases of the liver. It is now possible to increase the prothrombin in plasma, so that the blood clots normally, by giving vitamin K and bile ; provided, that is, that the liver is not so badly damaged that it cannot manufacture prothrombin. The natural vitamin, the structure of which was discovered in 1939, has a napthoquinone nucleus with a long phytyl tail. Fortunately, synthetic compounds, without the tail, are equally effective. They are now used in treatment of patients with liver diseases, and of new-born babies with a tendency to bleed, due, also, to deficiency of prothrombin.

It is now generally accepted that vitamin B1 forms a co-enzyme that is required in the intermediate metabolism of carbohydrates in the brain ; and it has recently been realized that the two vitamins, nicotinic acid and riboflavin, are embodied into compounds that act as carriers of oxygen for the oxidation of glucose. The part that these three vitamins play in the economy of the body is now settled. Here is the great difference between 1918 and 1940 ; in place of vague principles in some way necessary to health, we have substances of known chemical constitution which we can measure, the function of which in the working of the body we are beginning to understand. — (*Nature*, Vol. 146, p. 577.)

Synthetic Rubber in U. S. A.

It is announced that the leading rubber, oil and chemical companies of the United States have agreed to pool their patents and technical processes to construct plants with a capacity of 400,000 tons of synthetic rubber a year. The undertaking is expected to cost about £100,000,000.—(*Nature*, Vol. 149, p. 75.)

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Soil Nitrogen*

The nitrogen supply of the soil is of particular importance in India, where a tropical climate and cultivation over very long periods without addition of manures or fertilisers have combined to produce a general nitrogen deficiency. In general, there is less nitrogen in tropical than in temperate soils, but a greater proportion of the total nitrogen is in a form available to plants. In India, the main problem might be described as the immobilisation against leaching, rather than the mobilisation for plants, of soil nitrogen. Much attention is being paid to methods of stimulating natural processes of nitrogen fixation, and to the nature of nitrogen compounds in organic manures. Nitrogen added to the soil in inorganic fertilisers has the disadvantage of impermanence, and the part played in the nitrogen cycle by the carbon contained in organic manures has been the subject of several studies.

Evidence has been adduced to prove that there is more nitrogen fixation in soils mixed with energy-providing materials such as carbohydrates, cellulose, and fats in sunlight or artificial light than in the dark, although Azotobacter numbers are much greater in dark than in light. It is concluded that light is actually utilised in an endothermic chemical reaction of nitrogen fixation analogous to photo-synthesis in plants. Oxidation of carbohydrates is said to be capable of inducing photochemical fixation of nitrogen in the absence of micro-organisms but in the presence of suitable photocatalysts. Catalysts, among which the oxides of titanium, zinc, cadmium, aluminium, silicon, and magnesium are the most active, can also induce the oxidation of ammonia to nitrate in the presence of sunlight, short waves being particularly efficient. Free ammonia has been obtained by exposing amino-acids to sunlight in presence of humic acid.

The natural maintenance of soil fertility in humic tropical conditions has been explained on the basis of these conclusions in which, in the absence of photochemical nitrogen fixation, the rapid mobilisation of nitrogen and excessive leaching should reduce the nitrogen content of soils to vanishing point.

*Extracted from *Reports of the Progress of Applied Chemistry*, Vol. XXIV, Section on Soils and Fertilizers by G. V. Jacks. References to literature are here omitted.